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Microhabitat preferences for the errant scorpion, *Centruroides vittatus* (Scorpiones, Buthidae)

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Abstract. Vegetation as a preferred microhabitat for scorpions has rarely been considered despite many Buthidae (the bark scorpions) being non-burrowing errant scorpions that are active on both the ground and vegetation. Microhabitats can serve multiple functions for *Centruroides vittatus* (Say 1821), but a particular microhabitat can be preferred for a certain function such as a refuge, foraging, or feeding.

Observations of microhabitat use by *C. vittatus* were performed in Laredo, Texas of the Tamaulipan Biotic Province. Comparisons of microhabitat use by *C. vittatus* at different temperatures or precipitation levels were performed. Foraging and feeding by *C. vittatus* among microhabitat classes were also compared. The observed use of vegetation by *C. vittatus* during different seasons was compared to the expected use based on relative abundance of vegetation in the habitat.

Air temperature, but not precipitation, had a significant effect on microhabitat use by *C. vittatus*. Microhabitat had a significant effect on foraging of *C. vittatus* with caterpillars comprising 34.6% of the prey items and half of the scorpions feeding on caterpillars were in blackbrush (*Acacia rigidula*). The lowest proportion of scorpions observed feeding was on the ground (3.8%) and the highest in blackbrush (40.4%). The frequency of *C. vittatus* among vegetation classes was significantly different compared to the relative abundance of plant species in the plot. Scorpions were observed on prickly pear cactus (*Opuntia engelmannii*) and strawberry cactus (*Echinocereus enneacanthus*) at a higher frequency than expected, and scorpions were observed on guajillo (*Acacia berlandieri*) and tasajillo (*Opuntia leptocaulis*) at a lower frequency than expected. The frequency of scorpions on blackbrush was higher than expected during the spring.

Vegetation is an important microhabitat for *C. vittatus* in south Texas. The results indicate the possibility that *C. vittatus* in south Texas used various plant species to carry prey captured on the ground into vegetation to feed, used blackbrush to forage for caterpillars, and used strawberry and prickly pear cacti as a possible refuge.

Keywords: Habitat selection, foraging, refuge, feeding

Scorpions utilize a diversity of habitats (Hadley & Williams 1968; Polis 1990). Studies of habitat selection by scorpions have compared soil types for foraging (Polis & McCormick 1986a) or to build burrows (Polis & Farley 1980; Bradley & Brody 1984; Bradley 1988; Smith 1998). The effects of vegetation on scorpions has been considered in association with soil types (Bradley 1988), fire (Smith & Morton 1990), or as refuge from predation or cannibalism (Polis 1980a) including scorpions fleeing under vegetation to avoid predators because of low light levels (Camp & Gaffin 1999). However, vegetation as a preferred microhabitat for scorpions has rarely been considered despite many Buthidae (the bark scorpions) being non-burrowing errant scorpions that are active on both the ground and vegetation (Hadley & Williams 1968; Polis 1990).

Centruroides vittatus (Say 1821) (Scorpiones; Buthidae), the striped bark scorpion, has a wide distribution utilizing a number of different habitats (Shelley & Sissom 1995). Studies of habitat use by *C. vittatus* have already been done in the desert of west Texas (Brown & O'Connell 2000; Brown et al. 2002), in the deciduous forest of Arkansas (Yamashita 2004), and in the chaparral of south Texas (McReynolds 2004). This study will consider if *C. vittatus* has microhabitat preferences that can increase the fitness of the scorpion in the chaparral of south Texas.

Centruroides vittatus can utilize microhabitats for a refuge, foraging, or feeding. Many buthids will use vegetation or debris as a refuge during the day (Polis 1990). Refuges such as burrows can be used to avoid extreme temperatures during the day for many species of scorpions (Hadley 1974), and rocks and cracks in the ground can serve the same function for *Centruroides sculpturatus* Ewing 1928 (Crawford & Krehoff 1975) and *C. vittatus* (Brown et al. 2002). Vegetation could also be a refuge from extreme conditions such as high temperatures during the day or low temperatures at night. One possibility is that cacti such as Texas prickly pear cactus (*Opuntia engelmannii*), tasajillo (*Opuntia leptocaulis*) and strawberry cactus (*Echinocereus enneacanthus*) can be a refuge from these extreme conditions because the high water content in the cacti could provide a buffer from temperature changes due to the high specific heat of water.

Centruroides vittatus can climb into vegetation to forage or to feed on prey captured on the ground. Brown & O'Connell (2000) hypothesized that *C. vittatus* climbs into vegetation because of predator avoidance or higher prey availability. If feeding scorpions carry prey up vegetation to avoid ground predators (such as Lycosidae and Solifugae), then any vegetation can be used as a site to feed assuming that all plant species provides the same protection from ground predators. In addition, feeding scorpions carrying prey up vegetation from the ground should mainly feed on prey that is captured on the ground (Brown & O'Connell 2000). If scorpions are foraging in vegetation, then scorpions can be searching for prey found only in vegetation (e.g., lepidopteran caterpillars) and should prefer vegetation with high availability of these prey such as blackbrush (*Acacia rigidula*) and guajillo (*Acacia berlandieri*). Furthermore, scorpions can forage in the vegetation when prey availability in vegetation is higher such as during periods of high precipitation (see Polis 1979, 1980b).

Microhabitats can serve multiple functions for *C. vittatus*, but a particular microhabitat can be preferred for a certain function. This study will consider how certain conditions can affect microhabitat use by scorpions. Microhabitat use will be compared in relation to temperature and precipitation for possible shifts in activity among microhabitats. Microhabitat use will be compared in relation to prey capture and feeding to determine if scorpions are foraging in vegetation and/or carrying prey from the ground to vegetation. The observed use of trees, shrubs and cacti by *C. vittatus* during three time periods will be compared to a census of plant species. These comparisons are to determine if microhabitat selection was random or *C. vittatus* shows a preference for microhabitats during any seasonal periods.

METHODS

Study animal.—*Centruroides vittatus* has a wide distribution with Laredo, Texas in the southern portion of the distribution (Shelley & Sissom 1995). *Centruroides vittatus* is nocturnal with refuges during the day in debris, beneath vegetation, under bark, and in holes in the ground, but *C. vittatus* and other bark scorpions rarely dig their own burrows (Polis 1990). Scorpions emerge from their refuge only occasionally to forage (Polis 1980b; Bradley 1988; Warburg & Polis 1990). Different sized scorpions can be observed throughout the year with birth of *C. vittatus* between April and September and age of maturity of 36 to 48 mo (Polis & Sissom 1990). On nights of emergence, *C. vittatus* is active on the ground and/or in vegetation. Courtship by *C. vittatus* has rarely been observed and females carrying first instars observed only occasionally in the field (pers. obs.). Voucher specimens of *C. vittatus* were deposited in the invertebrate collection at Texas A&M International University.

Habitat.—This study was done on the campus of Texas A&M International University (27°35′N, 99°26′W), Laredo, Texas. Laredo is in the Tamaulipan Biotic Province that is characterized by low precipitation and high average temperatures (Blair 1950). The habitat of the research plots can be described as thorny brush (Blair 1950) or chaparral. Vegetation in the plots included blackbrush (*Acacia rigidula*), guajillo (*Acacia berlandieri*), honey mesquite (*Prosopis glandulosa*), Texas prickly pear cactus (*Opuntia engelmannii*), tasajillo (*Opuntia leptocaulis*), strawberry cactus (*Echinocereus enneacanthus*), cenizo (*Leucophyllum frutescens*), guayacan (*Guaiacum angustifolium*), leather stem (*Jatropha dioica*), lotebush (*Ziziphus obtusifolia*), Spanish dagger (*Yucca treculeana*), and other species. Three research plots of the campus were studied from 14 September 2000 to 8 August 2002 over 20 nights in 2000, 67 in 2001, 15 in 2002. The study continued from 28 August 2002 to 12 May 2005 in the main research plot over 21 nights in 2002, 52 in 2003, 46 in 2004, and 26 in 2005. At the start, three circular sites of 100 m^2 were placed in each plot to include different vegetation. Additional sites were placed at random in the main research plot, and these sites were first searched on 1 November 2000. The sites in the other two plots were abandoned 8 August 2002 because of construction nearby and light pollution from streetlights on the campus.

Data collection.—Scorpions were observed at night by locating the scorpion fluorescing under ultraviolet light (see Sissom et al. 1990). Observed scorpions were active and either out of or just emerging from their refuges. No data were collected on scorpions in their refuges to avoid destruction of the habitat. Scorpion data were collected after sunset between 19:30 Central Standard Time, USA (CST) at the earliest and 01:00 CST at the latest for an average of two hours per night of observation. Sites were selected at random and searched during a night of observation with a mode of three sites searched per night. Data were collected on all scorpions observed within or near the site. Data collected for each scorpion included date and time of observation, species of scorpion, microhabitat used, if prey was captured or not, and prey taxa. Air temperature was collected each night using a portable weather meter, Kestrel® 3000, from 16 July 2000 to 12 May 2005. Precipitation data were radar estimates for the field site that were provided by the Center for Earth and Environmental Studies, Texas A&M International University from 1 June 2003. Total precipitation for the two weeks just prior to the sample night was used for analysis because precipitation for the prior two weeks showed a significant effect on the prey availability in blackbrush (unpubl. data). All months of a year were sampled, but scorpions were rarely active during December and January. Scorpions can be active during all other months especially when the temperature is above 20° C during the night. Data collection occurred during 94 nights between January–April, 66 nights between May–August, and 115 nights between September–December.

The microhabitat data were placed in different classes: ground, grass, blackbrush, guajillo, prickly pear cactus, tasajillo, strawberry cactus, and other vegetation for the comparisons in this paper. If observed on soil, leaf litter, or a rock, the scorpion was considered on the ground. Grasses were not identified to species, but all other plants were identified to species if possible. Other vegetation included small trees that are rarely taller than 2 meters with the exception of a few mesquites and perennial shrubs such as cenizo, guayacan, leather stem, lotebush, and Spanish dagger. Mesquite was included in other legumes instead of other vegetation for the comparison of prey captured in different microhabitats. Annuals were rare in the habitat except for ephemeral wildflowers after heavy rains and scorpions were rarely observed climbing these wildflowers. Prey capture classes included no prey captured, caterpillars (Lepidoptera larvae), other insects (including adult Lepidoptera), and IGP (intraguild prey including Scorpiones, Araneae, Solifugae, and Chilopoda). Prey capture by scorpions can be observed as scorpions digest externally, thus prey items can be observed in pedipalps or chelicerae (Polis 1979).

Census of vegetation.—A census of plant species in the main research plot was performed on four randomly selected sites from the 12 sites in use during the summer of 2001 and the spring of 2002. Each circular site had all trees, shrubs and cacti within the 100 m^2 area identified to species and counted (Table 1). Grasses and ephemeral wildflowers were not sampled. The proportions of plant species in the four sites can be used to predict the expected frequency of scorpions on vegetation as if there was no preference in vegetation use (Table 1). Only scorpions on live vegetation that were included in the census were included in the comparisons (no scorpions on the ground, grass, ephemeral wildflowers, or dead vegetation). The observed vegetation use of *C. vittatus* in

Table 1.—The number, proportion (%), and estimated density of plant species censused from four random sites in the main research area during the summer of 2001 and spring of 2002. Each site was a circle with an area of 100 m^2.

Species	Common name	Number	Proportion (%)	Density (#/ha)
Acacia rigidula	Blackbrush	51	28.3	1275
Acacia berlandieri	Guajillo	33	18.3	825
Opuntia leptocaulis	Tasajillo	33	18.3	825
Opuntia engelmannii	Prickly pear cactus	12	6.7	300
Guaiacum angustifolium	Guayacan	12	6.7	300
Echinocereus enneacanthus	Strawberry cactus	5	2.8	125
Jatropha dioica	Leather stem	5	2.8	125
Prosopis glandulosa	Honey mesquite	2	1.1	50
	Other vegetation	27	15.0	675
	Total	180		4500

the main research plot during three time periods was compared to the expected vegetation use. The three time periods were based on a previous analysis of seasonal differences in microhabitat use (McReynolds 2004).

Data analyses.—Analysis of contingency tables (Model I) for effects on microhabitat and foraging used the G-test of independence (Sokal & Rohlf 1995). Planned comparisons were performed on a significant association for the contingency tables to test predictions on microhabitat preferences. The first planned comparison was among ground and vegetation. The second planned comparison was either to test for differences among vegetation classes that were predicted to be used for foraging (*Acacia* spp.), for refuges (cacti) and other vegetation or to test for differences in prey capture among legumes (*Acacia* spp. and *Prosopis glandulosa*) and other vegetation. Other comparisons were performed to complete the orthogonal comparisons. The replicated goodness of fit G-test was used to compare the observed vegetation use by *C. vittatus* for three time periods to the expected vegetation use based on the census of vegetation (Sokal & Rohlf 1995).

RESULTS

Effects on microhabitat use.—Air temperature had a significant effect on microhabitat use (Fig. 1). In planned comparisons, ground classes were significantly different from pooled vegetation classes, blackbrush classes were significantly different from guajillo classes, and grass classes were marginally significantly different from other vegetation classes (Fig. 1, Table 2). However, there was no significant difference among *Acacia* spp., cacti, or other vegetation classes (Fig. 1, Table 2). The proportion of scorpions on vegetation was highest at intermediate temperature class (20–25° C) and lowest at high temperature class (> 30° C) (Fig. 1). Precipitation for the two weeks prior to observations had no significant effect on microhabitat use (Fig. 2).

Foraging.—Microhabitat had a significant effect on foraging of *C. vittatus* (Fig. 3). In planned comparisons, ground was significantly different from all vegetation, and legumes were significantly different from other vegetation (Fig. 3, Table 3). Only a very small proportion of scorpions on the ground had prey compared to scorpions in vegetation. The scorpions in the legumes had a high proportion of caterpillars and other insects as prey while the scorpions in other vegetation and cacti had a high proportion of intraguild prey (IGP). The lowest proportion of scorpions observed feeding (n = 104) was on the ground (3.8%) and the highest in blackbrush (40.4%). Caterpillars were 34.6% of the prey items for *C. vittatus*, and half of the scorpions observed feeding on caterpillars were in blackbrush. Intraguild prey (IGP) were 17.3% of the prey items for *C. vittatus* with 9.6% Araneae, 3.8% Scorpiones, 1.9% Solifugae, and 1.9% Chilopoda.

Microhabitat preferences.—The proportion of *C. vittatus* on vegetation was compared to the expected proportion for three time periods (Fig. 4). The expected proportion assumed that scorpions have no preference for vegetation, and the distribution of scorpions on vegetation will be random relative to the abundance of plant species in the research plot (see Table 1). The proportion of scorpions on vegetation was significantly different from expected for all three time periods and the pooled data, and the three time periods were significantly heterogeneous (Fig. 4, Table 4). Scorpions were observed on prickly pear and strawberry cacti at a higher frequency than expected for every time period and the pooled data, and scorpions were observed on both guajillo and tasajillo at a lower frequency than expected for every time period and the pooled data. However, the frequency of scorpions on blackbrush was higher than expected during the January–April time period but lower than expected during the May–August time period and only slightly higher than expected during the September–November time class. The heterogeneity between time periods was due to fluctuations in the frequency of scorpions in the blackbrush and other vegetation classes.

DISCUSSION

Comparisons of scorpions have often noted the lack of activity on vegetation (Bradley 1988; Warburg & Polis 1990). One explanation for this pattern is that adaptation to a specialized habitat (sand) can reduce effectiveness in climbing (see Fet et al. 1998). However, bark scorpions (Buthidae) are known to be active on vegetation (Polis 1990). Microhabitat use of *Buthus occitanus* (Amoreux 1789) includes juveniles on bushes but not adults (Skutelsky 1996). In a study by Hadley & Williams (1968), *Centruroides sculpturatus* pursues prey up and down vegetation and under rocks and is more active than the other scorpion species. *Centruroides vittatus* in south Texas (present study) uses vegetation at higher frequency than in west Texas (Brown & O'Connell 2000) and in Arkansas (Yamashita 2004). Vegetation is important microhabitat for *C. vittatus* in Laredo, Texas with 54.1% on trees, shrubs or

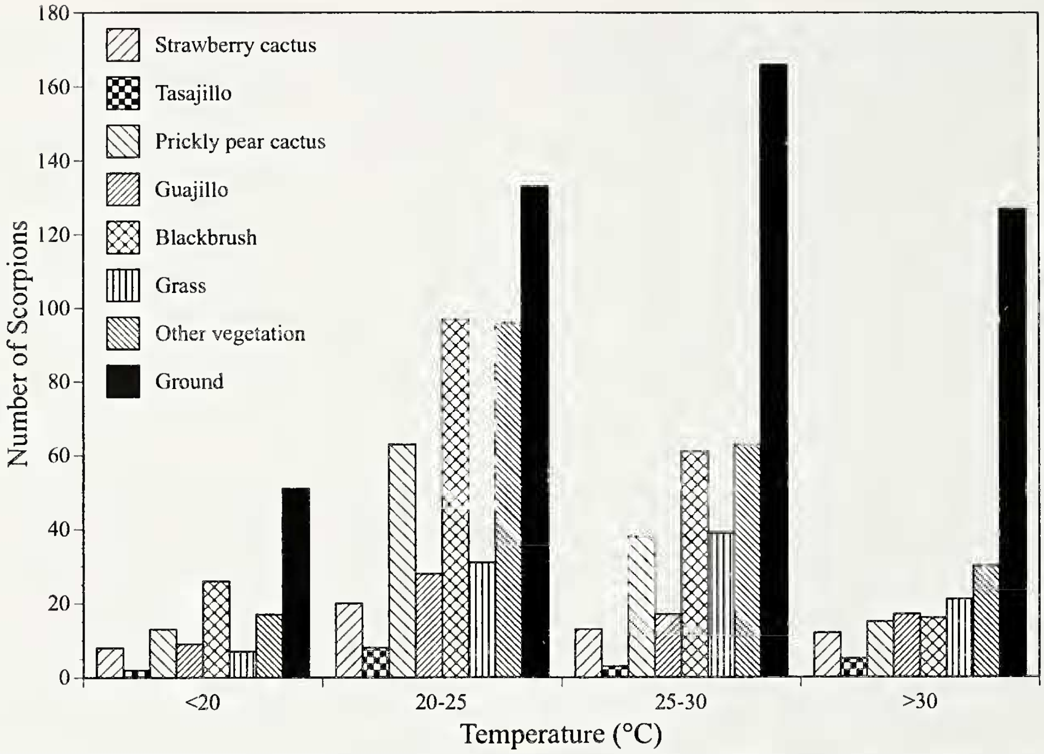

Figure 1.—The number of *Centruroides vittatus* using different microhabitats among temperature classes. The two *Opuntia* spp. classes, *O. leptocaulis* (tasajillo) and *O. englemanii* (prickly pear cactus), were pooled for the statistical analysis. The frequency of microhabitat use was significantly different among temperature classes ($G = 74.79$, $P < 0.001$, $df = 18$, $n = 1252$). See Table 2 for planned comparisons among microhabitat classes.

cacti; 7.8% on grass and only 38.1% on the ground. In other studies, *C. vittatus* were observed in trees (9.1%) and grass (10.6%) in Arkansas (Yamashita 2004) and 26.4% climbing vegetation in west Texas (Brown & O'Connell 2000).

Scorpion activity and thus microhabitat use can shift because of environmental factors (i.e., temperature and/or precipitation). The environmental factors can have a direct effect on the scorpion activity or indirectly on prey availability (Polis 1980a, 1988 but see Bradley 1988). Microhabitat use of *C. vittatus* shifted to the ground at high nocturnal temperatures. However, there was no support for the prediction that microhabitat use would shift from refuges in cacti to foraging in *Acacia* spp. with differences in temperature although the use of blackbrush was high during intermediate temperatures relative to guajillio. The high activity of scorpions on the ground at high temperatures (> 30° C) during the night does fit the pattern of high activity of *C. vittatus* on the ground during July and August as previously reported (McReynolds 2004). This can indicate low prey availability in vegetation and relatively higher prey availability on the ground during the hottest period of the year. Microhabitat use of *C. vittatus* did not shift with precipitation, and there was no evidence that foraging in blackbrush increased with high precipitation as predicted because of the observed increase in caterpillar availability with high precipitation (unpubl. data). One possible reason that activity and foraging behavior does not change with precipitation (and prey availability) is the threat of predation including cannibalism by adults on juveniles (see Polis 1980a, 1980b). Only adult *Paruroctonus mesaensis* (now *Smeringus mesaensis* (Stahnke 1957)) have a significant positive correlation with prey availability while the other age classes have a positive but not significant correlation (Polis 1980b).

Table 2.—Planned comparisons among microhabitat classes of the contingency table for microhabitat vs. temperature classes. The two *Opuntia* spp. classes, *O. leptocaulis* (Tasajillo) and *O. englemanii* (Prickly pear cactus), were pooled for the statistical analysis. NS = not significant. See Fig. 1.

Planned comparisons	*G*	*df*	*P*
Ground vs. All vegetation	43.71	3	< 0.001
Cactus vs. *Acacia* spp. vs. Grass and Other vegetation	8.71	6	NS
Opuntia spp. vs. Strawberry cactus	3.77	3	NS
Blackbrush vs. Guajillo	11.33	3	< 0.05
Grass vs. Other vegetation	7.27	3	0.1–0.05
Total	74.79	18	< 0.001

Scorpions can utilize different microhabitats and in particular different vegetation for feeding, foraging or refuge. Scorpion species can feed where the prey was captured, can carry prey to burrow (or other refuge) before feeding, or can carry it into vegetation. For example, *Parabuthus pallidus* Pocock 1895 carries prey back to the burrow but *Parabuthus leiosoma* (Ehrenberg 1828) feeds where prey is captured (Rein 2003). Scorpions with prey on vegetation are usually attributed to scorpions carrying prey from the ground into vegetation to feed (Polis 1979; Brown & O'Connell 2000). Only 3.8% of the scorpions with prey were on the ground in south Texas but many prey of *C. vittatus* were usually

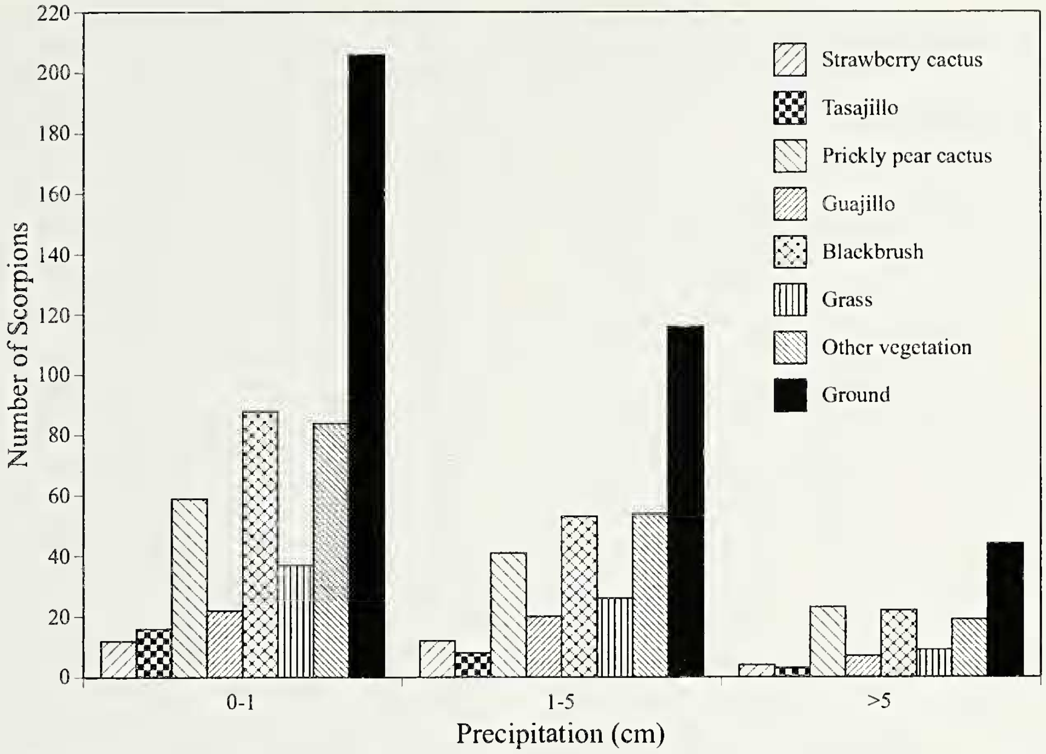

Figure 2.—The number of *Centruroides vittatus* using different microhabitats among classes of total precipitation for the prior two weeks. The frequency of microhabitat use was not significantly different among precipitation classes (G = 7.37, not significant, df = 14, n = 985).

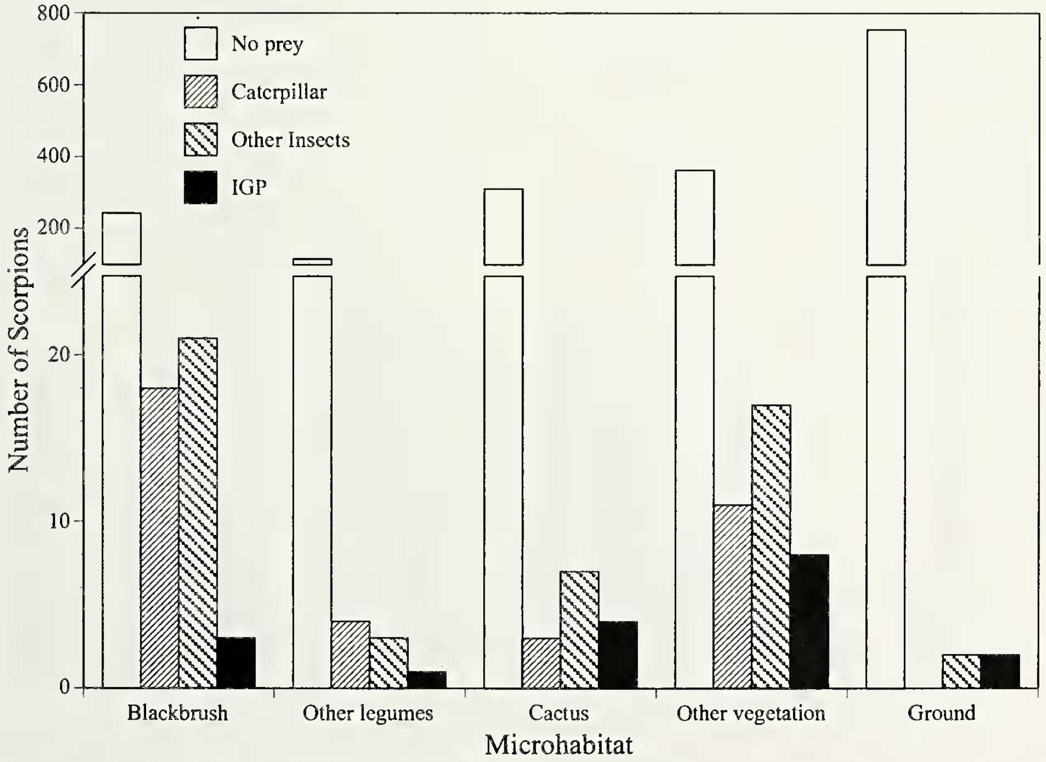

Figure 3.—The number of *Centruroides vittatus* using different microhabitats among prey capture classes. The frequency of microhabitat use was significantly different among prey capture classes (G = 112.17, $P < 0.001$, df = 12, n = 1890). See Table 3 for planned comparisons among microhabitat classes.

Table 3.—Planned comparisons among microhabitat classes of the contingency table for microhabitat vs. prey capture classes. NS = not significant. See Fig. 3.

Planned comparisons	*G*	*df*	*P*
Ground vs. All vegetation	83.77	3	< 0.001
Legumes vs. Cactus and Other vegetation	14.92	3	< 0.01
Blackbrush vs. Other legumes	6.53	3	NS
Cactus vs. Other vegetation	6.95	3	NS
Total	112.17	12	< 0.001

observed on the ground (e.g., many of the intraguild prey) (pers. obs.). Intraguild prey (including cannibalism) were 17.3% of the prey in south Texas as compared to 27.91% of spider prey and 9.30% cannibalism for *C. vittatus* in Arkansas (Yamashita 2004). These data indicate that *C. vittatus* in south Texas do carry prey captured on the ground into vegetation to feed. One possible function of moving prey (including intraguild prey) to vegetation is to avoid intraguild predation (see Bradley & Brody 1984; Polis & McCormick 1986b, 1987). Another possible function can be to avoid scavenging ants. Ants were observed causing feeding scorpions to move (pers. obs. by E. Lopez and C.N. McReynolds). Scorpions can also move between vegetation. A scorpion was observed feeding on a caterpillar on tasajillo but near a blackbrush where the caterpillars are available (pers. obs.). Perhaps this is to avoid ants or predators (e.g., other scorpions).

Foraging in vegetation has not been considered important for scorpions (Polis 1979) except for errant scorpions (McCormick & Polis 1990) and by juveniles (e.g., juvenile *Buthus occitanus* ambush prey in vegetation but not adults (Skutelsky 1996)). There was no evidence of foraging in vegetation by *C. vittatus* in west Texas (Brown & O'Connell 2000). However, the diet of *C. vittatus* in Laredo, Texas includes a number of items that have a high availability in trees or shrubs. Caterpillars were an important prey item for the scorpions in south Texas and most of the caterpillar taxa captured by *C. vittatus* were available in blackbrush (unpubl. data). Caterpillars are rarely reported as an important item in the diet for scorpions (see McCormick & Polis 1990). Caterpillars were only 1.4% of the diet for *P. mesaensis* (Polis 1979), and no caterpillars were reported for *C. vittatus* in west Texas (Brown & O'Connell 2000) but 11.6% of the prey for *C. vittatus* in Arkansas (Yamashita 2004) and 34.6% in south Texas (present study). It is predicted that scorpions foraging in blackbrush (and other legumes) will increase when caterpillar availability increases. However, scorpions prefer blackbrush only in January–April and there is no shift to blackbrush with high precipitation. If caterpillar availability is higher with the blooming of blackbrush in March and April, then this can explain why there is not an overall preference for blackbrush but there is a higher proportion of prey captured during March and April (McReynolds 2004) and the proportion of scorpions on blackbrush is higher than expected during the January–April time period.

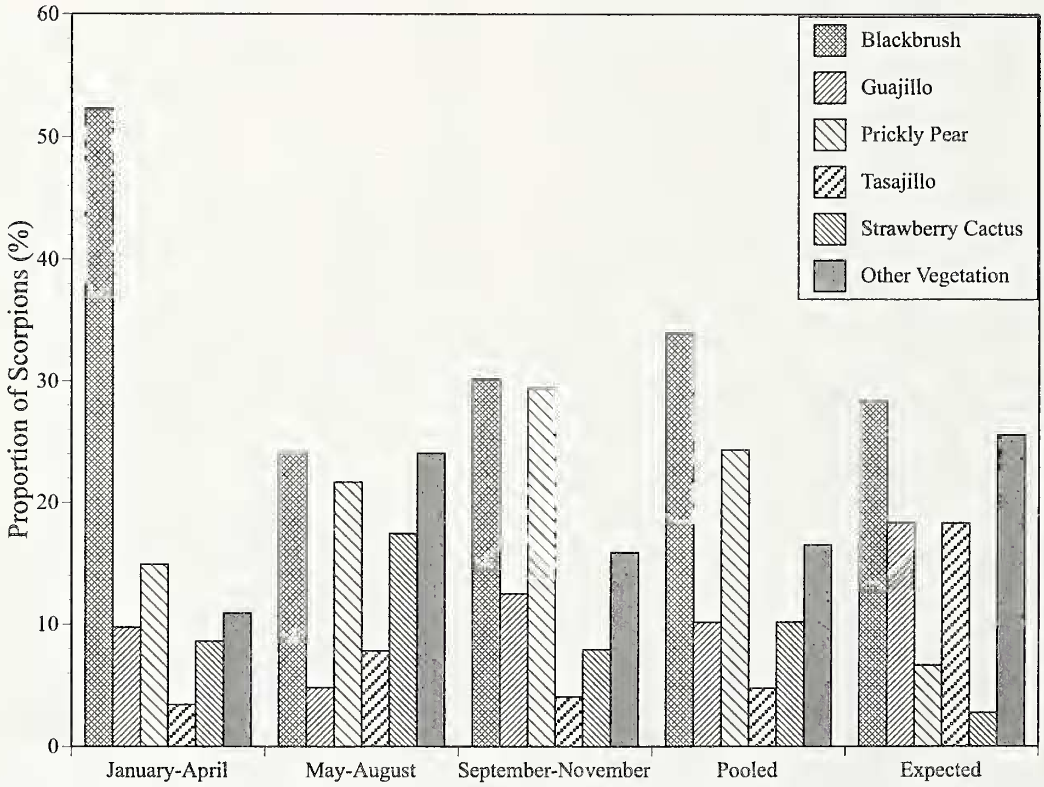

Figure 4.—The proportion (%) of *Centruroides vittatus* on vegetation during each seasonal time period compared to the expected proportion (%) on vegetation. The observed frequency of scorpions on vegetation from January to April (n = 174), from May to August (n = 166), from September to November (n = 415) and for the pooled data (n = 755) were compared to the expected frequency based on relative abundance of vegetation (see Table 1) in the replicated goodness of fit test (see Table 4).

Table 4.—Replicated goodness of fit test for microhabitat classes comparing the observed frequency of scorpions on vegetation to the expected frequency based on relative abundance of vegetation (see Table 1) during three seasonal time periods. See Fig. 4.

Time Periods	*G*	*df*	*P*
January to April	113.74	5	< 0.001
May to August	130.43	5	< 0.001
September to November	293.61	5	< 0.001
Pooled	473.47	5	< 0.001
Heterogeneity	64.31	10	< 0.001
Total	537.77	15	< 0.001

Most scorpion species dig a burrow, but many buthids do not dig their own burrow but use holes, space beneath rocks, and openings under bark and below vegetation as diurnal refuges (Polis 1990). *Centruroides vittatus* in west Texas have patchy distribution under rocks as diurnal refuges (Brown et al. 2002). Scorpions have been observed entering cracks or holes in the ground in south Texas (pers. obs.), but rocks are not available in the main research plot of this study. An alternative refuge for *C. vittatus* in south Texas can be a cactus because the high water content can provide a buffer from temperature changes due to the high specific heat of water. Scorpions have been observed going under the pads of a prickly pear cactus or down the openings between the stems of a strawberry cactus (pers. obs.). This can explain the higher than expected frequency of *C. vittatus* on strawberry cactus and prickly pear cactus in the research plot despite the low frequency of scorpions feeding on cacti and the low probability of foraging success because of the low prey availability on cacti (pers. obs.). This is assuming that *C. vittatus* is a central place forager (Orians & Pearson 1979) and there is a high probability that the scorpion would be near its refuge after emerging for the night (see Polis et al. 1985). However, *C. vittatus* has a lower than expected frequency in tasajillo. Perhaps tasajillo with thin stems and the more treelike structure does not provide the refuge that the prickly pear cactus or the strawberry cactus can provide. Sampling of potential refuges during the day at different temperatures will be required to establish diurnal refuge preferences of *C. vittatus* in south Texas (see Brown et al. 2002).

The high frequency of scorpions with prey in vegetation and low frequency on the ground indicates that *C. vittatus* carry prey caught on the ground into vegetation to feed. Foraging by *C. vittatus* especially in blackbrush for caterpillars has been demonstrated. However, the prediction that foraging scorpions will show a preference for blackbrush and other legumes was not supported. The frequency of scorpions in blackbrush did not increase with higher precipitation as is predicted because high precipitation increases availability of caterpillars in blackbrush. The frequency of scorpions in blackbrush was higher than expected in comparison to relative abundance of plant species only in January through April. It is possible that prey availability is higher early in the year especially March and April, but there is no evidence yet supporting this prediction. The results show that *C. vittatus* in south Texas used strawberry and prickly pear cacti with a higher than expected frequency in all time periods. However, the low frequency of scorpions with prey on cacti suggests that this preference for cacti was not for feeding or foraging, and perhaps scorpions were utilizing the cacti for another function such as a diurnal refuge.

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